Chapter 19 Multiple Choice Review

1. Complete and balance the following redox equation. When properly balanced using the smallest whole–number coefficients, the coefficient of S is
$H_2S + HNO_3 \rightarrow S + NO$ (acidic solution)

A. 1 B. 2 C. 3 D. 5 E. 6

2. Given the following notation for an electrochemical cell
$Pt(s) \mid H_2(g) \mid H^+(aq) \parallel Ag^+(aq) \mid Ag(s)$,
what is the balanced overall (net) cell reaction?

A. $2H^+(aq) + 2Ag^+(aq) \rightarrow H_2(g) + 2Ag(s)$
B. $H_2(g) + 2Ag(s) \rightarrow H^+(aq) + 2Ag^+(aq)$
C. $2H^+(aq) + 2Ag(s) \rightarrow H_2(g) + 2Ag^+(aq)$
D. $H_2(g) + Ag^+(aq) \rightarrow H^+(aq) + Ag(s)$
E. $H_2(g) + 2Ag^+(aq) \rightarrow 2H^+(aq) + 2Ag(s)$

3. Consider an electrochemical cell constructed from the following half cells, linked by an external circuit and by a KCl salt bridge.
- an Al(s) electrode in 1.0 M $Al(NO_3)_3$ solution
- a Pb(s) electrode in 1.0 M $Pb(NO_3)_2$ solution

The balanced overall (net) cell reaction is

A. $Pb(s) + Al^{3+}(aq) \rightarrow Pb^{2+}(aq) + Al(s)$.
B. $3Pb(s) + 2Al^{3+}(aq) \rightarrow 3Pb^{2+}(aq) + 2Al(s)$.
C. $3Pb^{2+}(aq) + 2Al(s) \rightarrow 3Pb(s) + 2Al^{3+}(aq)$.
D. $Pb^{2+}(aq) + Al(s) \rightarrow Pb(s) + Al^{3+}(aq)$.

4. Consider an electrochemical cell constructed from the following half cells, linked by a KCl salt bridge.
- an Al(s) electrode in 0.5 M $Al_2(SO_4)_3$ solution
- a Pb(s) electrode in 1.0 M $Pb(NO_3)_2$ solution

Which electrode is the *anode*?

A. Al B. Pb C. neither

5. Consider an electrochemical cell constructed from the following half cells, linked by a KCl salt bridge.
- a Fe electrode in 1.0 M $FeCl_2$ solution
- a Sn electrode in 1.0 M $Sn(NO_3)_2$ solution

When the cell is running spontaneously, which choice includes *only* true statements and no false ones?

A. The tin electrode loses mass and the tin electrode is the cathode.
B. The tin electrode gains mass and the tin electrode is the cathode.
C. The iron electrode gains mass and the iron electrode is the anode.
D. The iron electrode loses mass and the iron electrode is the cathode.
E. The iron electrode gains mass and the iron electrode is the cathode.

6. A certain electrochemical cell has for its cell reaction:
$Zn + HgO \rightarrow ZnO + Hg$
Which is the half–reaction occurring at the *anode*?

A. $HgO + 2e^- \rightarrow Hg + O^{2-}$
B. $Zn^{2+} + 2e^- \rightarrow Zn$
C. $Zn \rightarrow Zn^{2+} + 2e^-$
D. $ZnO + 2e^- \rightarrow Zn$

7. For the reaction, $2Cr^{2+} + Cl_2(g) \rightarrow 2Cr^{3+} + 2Cl^-$, $E°_{cell}$ is 1.78 V. Calculate $E°_{cell}$ for the related reaction $Cr^{3+} + Cl^- \rightarrow Cr^{2+} + ½\ Cl_2(g)$.

A. 1.78 V
B. 0.89 V
C. –1.78 V
D. –0.89 V
E. none of these

Multiplying the reaction by a constant does not change $E°$.

8. Consider the following electrochemical cell:
$U \mid U^{3+}(aq) \parallel Cl^-(aq), Cl_2(g) \mid Pt$
If the standard cell emf is 3.16 V, what is the standard reduction potential for uranium?
$3.16\ V = E°_{Cl^-/Cl_2} - E°_{U/U^{3+}} = 1.36\ V - E°_{U/U^{3+}}$; $E°_{U/U^{3+}} = -1.80\ V$
A. –3.16 V B. +3.16 V C. –1.80 V
D. +1.80 V E. +1.36 V

9. According to the following cell diagram, which chemical species undergoes reduction?
$Sn \mid Sn^{2+} \parallel NO_3^-$ (acid soln), $NO(g) \mid Pt$

A. Sn B. Sn^{2+} C. NO_3^- D. NO E. Pt

10. Which statement is *true* for a spontaneous redox reaction carried out at standard–state conditions?

A. $E°_{red}$ is always negative.
B. $E°_{cell}$ is always positive.
C. $E°_{ox}$ is always positive.
D. $E°_{red}$ is always positive.
E. $E°_{cell}$ is always negative.

11. Which one of the following reactions will occur spontaneously at standard–state conditions and 25°C?

A. $Mg^{2+} + Ca \rightarrow Mg + Ca^{2+}$
B. $Au + 3K^+ \rightarrow Au^{3+} + 3K$
C. $2Al^{3+} + 3Fe \rightarrow 2Al + 3Fe^{2+}$
D. $Cu + 2H^+ \rightarrow Cu^{2+} + H_2$

12. Consider the following standard reduction potentials in acid solution:

	E° (V)
$Al^{3+} + 3\ e^- \rightarrow Al\ (s)$	–1.66
$AgBr\ (s) + e^- \rightarrow Ag\ (s) + Br^-$	+0.07
$Sn^{4+} + 2e^- \rightarrow Sn^{2+}$	+0.14
$Fe^{3+} + e^- \rightarrow Fe^{2+}$	+0.77

The strongest reducing agent among those shown above is

A. Fe^{3+}. B. Fe^{2+}. C. Br^-. D. Al^{3+}. E. Al.

13. Which one of the following reagents is capable of transforming $Cu^{2+}(1\ M)$ to Cu(s)?

A. I^- B. Ni C. Al^{3+} D. F^- E. Ag

14. Which one of the following reagents is capable of transforming Br^- (aq) to $Br_2(l)$ under standard–state conditions?

A. I^- B. NO_3^- C. Ag^+ D. Al^{3+} E. Au^{3+}

15. Consider the following reaction:

$$2Fe^{2+}(aq) + Cu^{2+} \rightarrow 2Fe^{3+}(aq) + Cu.$$

When the reaction comes to equilibrium, what is the cell voltage?

$E_{cell} = 0$ at equilibrium (definition)

A. 0.43 V B. 1.11 V C. 0.78 V
D. –0.43 V E. 0 V

16. For the electrochemical cell

$$Pt(s) \mid H_2(1\ atm) \mid H^+(1\ M) \parallel Cu^{2+}(1\ M) \mid Cu(s),$$

which one of the following changes will cause an *increase* in the cell voltage?

A. Lower the $H_2(g)$ pressure.
B. Increase the size/mass of the copper electrode.
C. Lower the $H^+(aq)$ concentration.
D. Decrease the concentration of Cu^{2+} ion.
E. none of these

17. Consider an electrochemical cell with the following cell reaction where all reactants and products are at standard–state conditions:

$$Cu^{2+}(aq) + H_2(g) \rightarrow Cu(s) + 2H^+(aq).$$

Predict the effect on the emf of this cell of adding NaOH solution to the hydrogen half–cell until the pH equals 7.0.

A. The emf will increase.
B. The emf will decrease.
C. No change in the emf will be observed.

18. If the measured voltage of the cell

$$Zn(s) \mid Zn^{2+}(aq) \parallel Ag^+(aq) \mid Ag(s)$$

is 1.37 V when the concentration of Zn^{2+} ion is 0.010 M, what is the Ag^+ ion concentration?

See solution below

A. 2.5 M
B. 4.0×10^{-9} M
C. 6.2×10^{-3} M
D. 2.6×10^{-51} M
E. 6.2×10^{-5} M

19. Which one of the following reactions must be carried out in an electrolytic cell rather than in a galvanic cell?

$E^\circ_{cell} = E^\circ_{Al/Al^{3+}} - E^\circ_{Br^-/Br_2} = -1.66\ V - (1.07\ V) = \boxed{-2.73\ V}$

A. $Zn^{2+} + Ca \rightarrow Zn + Ca^{2+}$
B. $Al^{3+} + 3Br^- \rightarrow Al + \frac{3}{2}Br_2$
C. $2Al + 3Fe^{2+} \rightarrow 2Al^{3+} + 3Fe$
D. $H_2 + I_2(s) \rightarrow 2H^+ + 2I^-$

20. The half–reaction that occurs at the cathode during electrolysis of an aqueous $CuCl_2$ solution is

A. $Cu^+ + e^- \rightarrow Cu$.
B. $Cu^{2+} + e^- \rightarrow Cu^+$.
C. $2H_2O + 2e^- \rightarrow H_2 + 2OH^-$.
D. $Cl_2 + 2e^- \rightarrow 2Cl^-$.
E. $2Cl^- \rightarrow Cl_2 + 2e^-$.

21. Aluminum does not corrode as does iron, because

A. Al does not react with O_2.
B. a protective layer of Al_2O_3 forms on the metal surface.
C. Al is harder to oxidize than is Fe.
D. Fe gives cathodic protection to Al.
E. the electrical circuit cannot be completed on an Al surface.

22. Iron objects such as storage tanks and underground pipelines can be protected from corrosion by connecting them through a wire to a piece of

A. Pb. B. Ag. C. Sn. D. Mg. E. Cu.

18. $E^\circ = E^\circ_{Ag/Ag^+} - E^\circ_{Zn/Zn^{2+}} = 0.80\ V - (-0.76\ V) = 1.56\ V$

$$E = E^\circ - \frac{0.0257\ V}{n} \ln \frac{[Zn^{2+}]}{[Ag^+]^2};$$

$$1.37\ V = 1.56\ V - \frac{0.0257\ V}{2} \ln \frac{(0.010)}{[Ag^+]^2}$$

$$\ln \frac{0.010}{[Ag^+]^2} = \frac{(1.56\ V - 1.37\ V) \times 2}{0.0257};$$

$$\frac{0.010}{[Ag^+]^2} = 2.62 \times 10^6;\ [Ag^+] = \boxed{6.2 \times 10^{-5}\ M}$$